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EVALUATION OF THE DISTURBANCE CAUSED BY AIRCRAFT NOISE BY OPINION SURVEYS

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16. Abstract

Evaluation of the disturbance caused by aircraft noise through the use of questionnaires relating to activities which may be disturbed. On this basis, using the questionnaire as a scale rather than considering isolated question responses, the evaluation is seen as more objective.

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EVALUATION OF THE DISTURBANCE CAUSED BY AIRCRAFT NOISE BY OPINION SURVEYS

Jacques Bremond[1]

Summary

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Questionnaires intended for the evaluation of the disturbance caused by aircraft noise include a series of questions relating to activities which may be disturbed (behavioral elements).

On the basis of this set of questions established as a scale, it is possible to evaluate this disturbance more objectively than from isolated questions, from a single general question or a factor analysis.

The most appropriate method (Guttman hierarchic scale, "scale analysis" in English) is described. The author furnishes experimental proofs of its worth, based on investigations conducted by the author on the evaluation of the disturbance caused by the noise of light aircraft, and on the disturbance which might be caused by the Concorde around the Washington International Airport.

It is recommended[2] that the questionnaires of the opinion surveys on aircraft noise should have a standardized structure, which includes among others, a set of questions permitting the analysis of the disturbance caused in different daily activities.

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[1]Center of Air Psychology Studies and Research (CERPAIR) Air Base 272-78210 Saint Cyr L'Ecole.

[2]Recommendations no. 2/3 of the Special Meeting on Aircraft Noise [organized by the OACI (27 November to 17 December 1969 in Montreal)].

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The statistical processing of the answers to these questions, intended to achieve the most reliable possible evaluation of the disturbance felt by persons living near airports raises certain methodological problems which will be discussed below.

1. Need for Establishing an Attitude Scale

1.1 Characteristics of the Questions Raised

The questionnaires normally include the following question (or a similar form) which actually includes at least 9 elements which could be called "behavioral."

We give below a certain number of daily activities. Which of them are disturbed by aircraft noise, so far as you are concerned? Would you say that the noise of the aircraft:

-- prevents you from falling asleep
-- disturbs you in your conversations
-- disturbs you when you listen to the radio or TV
-- disturbs the reception of the TV picture
-- prevents you from concentrating when you read, write, etc...
-- prevents you from relaxing, from resting
-- frightens you
-- makes you nervous, irritable
-- causes vibrations in your house

To these items we may add occasionally:
-- prevents you from opening the windows in summer
-- wakes you up earlier than you wished
-- disturbs you during your meals
-- disturbs you in your work
-- startles you

The answers proposed are of several types: "opinion thermometer" in 5 degress (coded from 0 to 4, or 1 to 5); frequency of disturbance,

never, occasionally, fairly often, very often; intensity of the disturbance: none, a little, rather great, very great (for the last 2 types, coding from 0 to 3, or 1 to 4). Thus each person questioned is given a score.

This question with 9 items is often preceded by another more general question meant for overall assessment of the annoyance: Does the aircraft noise which you hear around these parts disturb you a little, fairly much, very much, not at all?

We will thus be faced with a mass of data which will have to be processed as well as possible to obtain a valid assessment of the disturbance of persons living near the airports.

1.2 Use of Isolated Questions

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The first idea may be to use the general question to evaluate the disturbance and introduce shades by considering the answers to the other "behavioral" items. Then the percentages are calculated on the total number of persons questioned or per area of exposure to noise, or we give a tabulation of the relationships between these elements and certain individual biographic, socio-economic, geographic characteristics, etc... The questions asked are therefore examined one by one, or 2 by 2. The synthesis of the answers to part or all these items is difficult, even impossible for the human mind, even if statistical methods such as chi squared or variance analysis are used.

Another characteristic of this processing of isolated questions is that we are at the level of opinions and not attitudes. An attitude may be defined as the disposition or tendency to react to a certain object in one way rather than another. It may also be stated that the attitude represents the relations existing between habitual opinions. This disposition has a relative duration, and it is the coherence of the opinions which imparts a certain stability to it.

Processing of isolated questions should also be avoided because there is not a prior proof that the persons questioned are really concerned by the problem referred to in the questions asked. In other words, we have no proof beforehand that the persons questioned have a coherent position on the problem unless this problem is explored by several questions, and this coherence is established by the relations observed between the answers to the questions exploring the dimension which we wish to evaluate.

The best means of achieving this goal is therefore to establish an attitude scale.

1.3 Establishment of an Attitude Scale (Evaluation of the Disturbance)

Many authors adopt the following procedure. Considering all the above-listed items, they retain some of them by an intuitive selection, and calculate for each individual a total score corresponding to the arithmetical sum of the scores for each of the questions retained: for 9 items, each marked from 0 to 3, the score may be between 0 and 27. By proceeding in this manner, they assume beforehand that the items included in the scale, on one hand, are really part of the dimension assessed, and on the other hand, share equally in the disturbance.

Actually it is absolutely necessary to submit these hypotheses to the verdict of facts by calculating the statistical relations existing between the answers given by each individual to all the questions on this topic. These relations may be of different types: co-frequency, co-variation item test (Likert scales), co-variancy (homogeneous keys of Dubois-Loevinger), inclusion (Guttman scales); the above list, which is not exhaustive, corresponds to closer and closer relations, therefore to an increasingly great coherence between the answers.

Therefore, the most appropriate method seems to be that of

hierarchic analysis of Guttman ("scale analysis" in English), because by eliminating a certain number of questions, it permits the simultaneous definition of the assessed dimension (in the double sense of determining and demarcating) and obtaining a measurement tool, that is, a scale.

But this method permits even more: it furnishes the proof of the existence of an underlying dimension to the group of questions posed. In other words, if it is impossible to establish a Guttman scale, it means that the persons questioned do not reveal a coherent attitude to the problem in question.

It is easy to verify whether a scale is valid for a population group other than the one for whom it was established, by calculating certain coefficients estimating the metric qualities of the measurement instrument. These criteria of quality of a Guttman scale are discussed in the Appendix.

2. Compared Experimental Data

The results of the surveys show that this scale method is a necessary, and also a sufficient condition for assessing the disturbance caused by the noise of aircraft.

2.1 Definition of the Content of a Dimension

The "heuristic" capacity (that is the capacity for discovery) of the Guttman method is revealed particularly by a study conducted in France in 1970 on the "Reactions of French Communities to the Supersonic Boom" [1] produced by military aircraft.

Eleven items were put forward in an identical manner to assess the disturbance caused by noise in general and the disturbance

caused by the boom. It was proved that in each case a single scale could be established and that the elements involved in these 2 scales were not the same, thus proving that the 2 types of disturbance were of different nature. The initial hypothesis was that the supersonic boom should be considered as a noise, and had the same behavioral effects (that is, disturbed the same activities) as noise in general and the noise of aircraft in particular, a hypothesis which was refuted by the search for a Guttman scale.

These scales consisted of the following items: /271

a. Disturbance caused by noise
   The noise of the aircraft:
   -- disturbs your work or your daily activities
   -- disturbs your sleep
   -- disturbs your conversations
   -- disturbs you when you are listening to the radio or watching TV
   -- causes vibrations in your house

b. Disturbance caused by the boom
   The boom
   -- disturbs your work or your daily activities
   -- frightens you
   -- makes you nervous
   -- startles you.

Thus it may be seen that the content of the disturbance caused by the boom has a large emotional component which makes it impossible to dissociate it from its psychological repercussions, unlike noise for which the behavioral aspects can be distinguished much more easily from the other components.

2.2 Choice of a Method of Establishing the Scale

Apart from the 2 above-mentioned procedures (Para 1.3), there is a third, more burdensome one: factor analysis, which makes it possible to obtain the main factors taking into account the variancy of the results, to choose the questions which will form the scale as a function of their kinship (saturation) to the corresponding factor, and to assign them a weight proportional to their significance in the total disturbance. Finally, each individual may receive a factorial score on each of the factors isolated by the analysis. Naturally it must be shown in a first stage that there exists a very definite "disturbance" factor. Therefore, the factor analysis plays here the same role as the method of the Guttman scale: it shows the existence of a problem by the coherence of the answers of the persons questioned.

These last 2 methods were compared during a study conducted in France in 1977 on "The Disturbance Caused by General Aviation" [2]. The results were compared with those of a certain number of studies carried out in France in 1973 around Orly [4] and in other countries: U. S.: TRACOR studies, 1970 [7] and TRACOR 1972 [8]; in Great Britain, studies by McKennel (1963) [5] and 1977 [6]. The correlations found between the levels of exposure to noise and the disturbance assessed by different types of scales have been indicated in the tables of the next page.

The questionnaire used for the study conducted in France on the disturbance caused by civil aviation contained a set of 11 questions, including the 9 mentioned in Para 1. 2 Guttman scales were established, one with 6, the other 8 items, both having excellent metric qualities.

The answers were coded in 2 ways: in the first stage, a simple dichotomy was used, i.e., the negative answers were rated as 0, while the affirmative answers were rated as 1, whether the answers are "occasionally," "fairly often," or "very often." In a second stage, the answers were weighted (hence the name of weighted

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TABLE 1

CORRELATIONS BETWEEN THE LEVELS OF EXPOSURE TO THE NOISE OF AIRCRAFT AND OF ASSESSMENT OF THE DISTURBANCE. STUDIES IN FRANCE.

	France 1977 - General Aviation					France 1973 Orly
	simple scale 6 items (Guttman)	weighted scale 6 items (Guttman)	simple scale 8 items (Guttman)	weighted scale 8 items (Guttman)	factor score	factor score
correlations with the levels of exposure to the noise of aircraft	.37	.41	.37	.41	.32	.21
exposure indicator	psophic index					

TABLE 2

CORRELATION BETWEEN THE LEVEL OF THE EXPOSURE TO NOISE OF AIRCRAFT AND DIFFERENT MEANS OF ASSESSMENT OF THE DISTURBANCE. STUDIES ABROAD.

	Great Britain Studies McKennel-Heathrow		USA Studies TRACOR		USA Studies CERPAIR 1977	
	1961 simple scale 5 items (Guttman)	1977 scale weighted beforehand 5 items	1970 scale weighted beforehand 9 items	1972 scale weighted beforehand 9 items	weighted scale	
					Washington	New York
correlations with the levels of exposure to aircraft noise	.39	.26	.41	.25	.27	.53
exposure indicator	PNdB	EPNdB	Composite Noise Rating - CNR		Noise Exposure Forecast - NEF	

scale), that is, the answers "occasionally" were rated as 1, those with "fairly often" as 2, and the "very often" as 3; the negative answers are still rated 0. It was hoped to increase the discriminative capacity of the scales thus, by giving more weight to the extreme answers.

A prior factor analysis had shown the existence of a very isolated factor representing the disturbance caused by the noise of aircraft in which the items retained for the 2 Guttman scales had practically the same saturation in this factor. This made it possible to assign the same weight to each item in both the scales. Finally, a factorial score was calculated on the basis of the saturated questions in this disturbance factor, behavioral items and other questions listed in the questionnaire.

The correlations with the psophic index of noise exposure were calculated for these 6 methods of assessment.

The examination of Tables 1 and 2 shows on one hand that weighting of the answers improves the correlations with the levels of exposure to aircraft noise; on the other hand, that an 8-item scale provides no further information. Finally, the use of a factor score gives much less satisfactory results. In view of the burden represented by the calculation of an individual factorial score, the 6-item Guttman weighted scale proves to be the best. We give for the sake of comparison, the correlation obtained in 1973 around Orly using a factorial score on the basis of the same set of questions as in the 1977 study. On the other hand, a factor score would include ipso facto other variables beside the disturbance proper.

We may mention that we had used the same procedure to assess the disturbance caused by the noise of the Concorde around the international Washington-Dulles airport [3].

Let us now discuss the studies conducted in other countries.

In the U.S., the two TRACOR studies of 1970 and 1972 used an a priori scale of 9 identical items in both cases. The fluctuation of the results between the 2 studies may be seen. But it should be noted that a prior factor analysis had verified the homogeneity of the 9 items.

In Great Britain, the studies by McKennel merit a more attentive /273 examination. In 1961, this author adopted the Guttman method to establish a 5-item scale (4 explicit items, a fifth one called "miscellaneous" and referring to various spontaneous answers). In 1977, he used the same 5 items, weighting the answers but without prior verification that they represented a scale according to the method of Guttman. This is very probably the cause of the decrease in the value of the correlation coefficient, in spite of using in 1977 an exposure indicator (EPNdB) acknowledged as representing better the noise perceived by a human being.

3. Conclusion

The procedure recommended to assess disturbance caused by aircraft noise in an opinion survey is therefore as follows:

-- establish as many items as possible relating a priori to the activities disturbed by the noise of aircraft
-- calculate by different coefficients the coherence of the answers given to these different items (calculation of inclusion according to the Guttman method in particular)
-- choose a scale of at least 6 items whose metric qualities are verified
-- calculate an individual score of disturbance by weighting the answers to the different items of the scale retained.

At that point, it becomes possible to perform all the calculations usually made in opinion surveys. It goes without saying that this procedure is applied whenever we wish to establish an attitude scale in psycho-sociology.

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APPENDIX

1. Quality Criteria of a Guttman Scale

A scale established by the Guttman method consists of, for example, items related mutually by a relation of inclusion. This relation implies that when an affirmative answer was given to a question, it is highly probable that a positive answer be given to all the following ones in the order in which they appear on the scale which is the order of increasing percentages of positive answers.

In the case of a disturbance scale, the most highly disturbed persons are those who give the answers rated "plus" to the first answer (therefore to the next ones); the least disturbed ones are those whose answers are rated "minus" to the last (therefore to the previous ones). The persons occupying an intermediate position give a series of positive answers, then a series of negative answers. In this case, we may say that the set of answers of each subject forms a "perfect pattern."

Questions	Q1	Q2	Q3	Q4	Q5
Subjects					
S1	+	+	+	+	+
S2		+	+	+	+
S3			+	+	+
S4				+	+
S5					+
S6					

If 1 point is given for each positive answer and 0 to each negative answer, we can, if we know a person's score, re-establish his or her answers to all the questions of the scale: we say that there is perfect reproducibility. The previous scheme also renders this fact concrete.

Practically it is impossible to establish perfect scales. We

will therefore have to calculate by how far a scale deviates from perfection. To this end, Guttman introduces concepts of errors and imperfect patterns.

We say that there is an error in the pattern if as compared with any perfect pattern there is a "plus" instead of a "minus" and conversely. /274

The number of errors of a pattern is defined as the minimum number of errors obtained by comparing the pattern considered with all the perfect patterns.

If there are too many imperfect patterns, it will affect the monodimensional nature of the scale. Guttman proposed a reproducibility coefficient taking into account the total number of errors in the scale. This coefficient is as follows:

$$C.R. = 1 - \frac{\Sigma e}{m\,n}$$ in which

Σe is the total number of errors for all the patterns
n is the number of subjects
$m\,n$ is the total number of answers

C.R. has a maximum equal to 1, in case there is no error. C.R. must be higher than 0.92 for the scale to be good.

2. Green Criterion (K)

Green proposed the assessment of a scale by comparing the CR obtained with CRm, which is the CR of a pseudo-scale established with independent items having the same percentage as those of the scale. We therefore calculate the following coefficient:

$$K = \frac{CR - CRm}{1 - CRm}$$

If we confine ourselves to the approximation of the first order (error of the "plus minus" type for 2 adjacent items), the following formula is used:

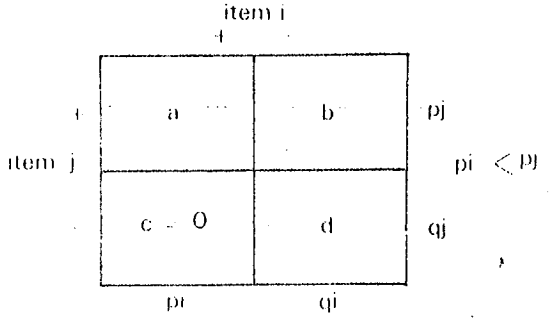
$$K = 1 - \frac{\Sigma\, ci,\, i+1}{\Sigma,\, pi\, qi+1}$$

ci, i + 1 is the relative + - frequency for 2 adjacent items i and i + 1.

It is assumed that K > 0.25 characterizes a good scale.

3. Loevinger Criterion (H)

If the questions form a perfect scale, it follows that these items are classified by increasing + percentages and that, if any 2 items are extracted i and j of this scale, maintaining their order, these items are related by the following inclusion relation:



If the scale is perfect, there is no error, all the cij are equal to zero and all the coefficients of hierarchization of two items are equal to 1.

$$hij = 1 - \frac{cij}{piqj}$$

Practically a scale is not perfect and the hij are not equal to 1. We choose therefore the items to which the best values of h

correspond.

Loevinger proposed the calculation of a coefficient from inclusion values calculated for all the pairs of items. The generalized inclusion coefficient is also called homogeneity coefficient H, the weighted average of the hij:

$$H = \frac{\sum_{i \neq j} p_i q_i h_{ij}}{\sum_{i \neq j} p_i q_j}$$

In this formula the value of hij given above we obtain

$$H = 1 - \frac{\sum_{i \neq j} c_{ij}}{\sum_{i \neq j} p_i q_j}$$

H = 1 characterizes a perfect scale

H = 0 corresponds to a scale consisting of independent items.

It is assumed that a scale is only good if H > 0.30. Note that the Green coefficient is quite similar to H, while the difference lies in the fact that the summation is carried out on the m - 1 pairs of adjacent items for the Green coefficient, and it is implemented on the possible pairs of items for the Green coefficient, while it is done for the $\binom{m}{2}$ possible pairs of items for the H coefficient.